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EARLY WARNING AND THE TANK

FRED L. BUNN

JUNE 1989

U.S. ARMY LABORATORY COMMAND

BALLISTIC RESEARCH LABORATORY
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This report considers the value of early warning to a tank in defense and offense. It discusses the location, activities, and reaction times of crewmen and compares the times for a crew to reach combat readiness with and without early warning. It concludes that early warning may be of value for the defender and of lesser value to an attacker.

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EARLY WARNING AND THE TANK

INTRODUCTION

A review of very old reports analyzing tank combat in World War II and the Korean war suggest that early warning is vital for the tanker.

There is no detailed data with which to model the effects of early warning. However, in an effort to quantify the benefits and gain an understanding of the process, I have made some assumptions and performed an analysis which is one step removed from a back of the envelope study. In this analysis there is no preliminary artillery barrage.

RELEVANT INFORMATION

The following are relevant quotes from the literature:

1. A 1954 study of Korean War armored combat[1] says,

> 6. Spotter aircraft, when used by tank battalions, instilled additional confidence in these units, provided excellent means of gaining flank security in rapid advance and retrograde movements, and were especially helpful in spotting enemy vehicles and in directing the fire of lead tanks.
>
> 7. Spotter aircraft were used in only 13 percent of the actions studied, but they would have substantially improved chances of success in 64 percent of the actions, and were urgently needed in 40 percent of actions lost.
>
> 10. US tanks fired first in action about 60 percent of the time, although this advantage was rather unevenly divided among tank types. However, the ability to fire first appears to have enhanced the effectiveness by a factor of at least 6.
>
> 11. The presence of enemy tanks was known prior to the beginning of actions in 35 percent of the cases studied, and under these conditions the effectiveness of US tanks was almost four times as great as when the enemy was not detected before the actions were imminent.

2. "Historically, 25 percent of tanker casualties occurred when the tank crewman was outside his tank. Tankers spend over 90 percent of their time outside their tanks, APC's and other armored vehicles[2]."

3. A 1952 report of WWII tank engagements[3] says, "He (the defender) fires first 80% of the time."

REASONS FOR EARLY WARNING

Early warning may be valuable for the following reasons:

1. Surprise is removed.
2. The tank crewmembers can reach their stations, be prepared, and alert.
3. The proper ammo can be loaded.
4. Search sectors may be reduced.

[1]Vincent V. McRae and Alvin D. Coox, *Tank-vs-Tank Combat in Korea*, Operations Research Office, Johns Hopkins University, Chevy Chase, MD, Sep 1954, p3.
[2]James F. Dunnigan, *"How to Make War,"* Quill, NY, 1983, p55.
[3]Herbert K. Weiss, *"Some Mathematical Models of Tank Combat,"* BRL MR No. 724, September 1953, Ballistic Research Laboratory, Aberdeen Proving Ground, MD., p19.

5. Guns may be aimed in the general direction of the expected target.
6. Approximate range may be fed to the fire control.

ASSUMPTIONS ABOUT THE DEFENDER

The time for a crew to reach battle stations and be ready to fight obviously depends on the prior locations, activities, and reaction times of the individual crewmen. Unfortunately, there is no such data for crewmen in situations where a crew has or lacks early warning. In the defense and lacking early warning, it is likely that one man will be appointed to stand watch and that the crewmen will generally be outside the tank. Since combat is a 24 hour a day job, they will often snatch sleep when they can, and will be involved in maintenance a good fraction of the time.

After making the following estimates for crew location, activity, and response times, I showed them to an Abrams master gunner for a sanity check; he found them reasonable.

Location of Crewmen

In the absence of data, a reasonable estimate of the location of the crewmen is as follows:

When warned:
100% of crew on board.

When unwarned:
70% of time a given crewman is off vehicle
30% of time a given crewman is on vehicle

Activity of Crewmen

In the absence of data, a reasonable estimate of the activity of the crewmen is as follows:

When warned:
90% of time all crewmen are searching (driver has limited vision).

When unwarned:
100% of the time, one crewman is standing watch
39% of the time, a non-watch crewman is asleep.
61% of the time a non-watch crewman is awake.
20% of the time a non-watch, awake crewman is searching.
80% of the time a non-watch, awake crewman is doing other activities.

If the average crewman sleeps s hours, then the fraction of hours he is awake is:

$$f = (24\text{-}s)/24$$

and the number of hours the n crewmen are awake is:

$$24nf$$

Assume that 1 of the n crewmen is on watch when the tank is in a defensive position. Let p be the probability a given crewman off watch is awake. Then the number of hours awake is:

$$24 + 24p(n\text{-}1)$$

Equating these, we have:

$$24 + 24p(n\text{-}1) = 24nf$$

Solving for p:

$$p = \frac{nf - 1}{n - 1}$$

For a four man crew, with seven hours of sleep per day, f = 17/24 and p = 0.61.

Response Time of Crewmen

The time to reach battle stations and be prepared to fight will vary depending on the location and activity of each crewman. Reasonable estimates of the median time for each crewman to be ready to fight are as follows:

0.2 sec	crewman on board and searching
2 sec	crewman on board and misc activities
5 sec	crewman on board and sleeping
5 sec	crewman outside and searching
7 sec	crewman outside and misc activities
10 sec	crewman outside and sleeping

The actual times will vary around the median time. Human response times for other activities are distributed log-normally, with 0.5 standard deviation and in the absence of data, we can assume the same distribution for the time to reach battle readiness.

All members of a defending tank must be on board and ready to fight before the tank can begin to do so. This means that the time to begin to fight is the time the last crewman is ready to fight. If a crewman is outside sleeping, he must become fully alert, dash to the tank, slip inside, perhaps close his hatch, put on his helmet, and begin performing his duties.

This is a hazardous time; if the main gun is fired in panic while crewmen are not wearing ear protection, they experience temporary hearing loss and crew communications suffer. If the main gun is fired while crewmen are entering hatches, they may suffer falls, broken bones, or concussions. If the coax is firing while the driver is mounting the tank, he may find unneeded holes in his body. If the driver moves the vehicle while another crewman is mounting it, further injuries are possible.

ASSUMPTIONS ABOUT THE ATTACK

When moving, all crewmen will obviously be onboard; however, the driver will be concentrating on his driving and is unlikely to be the one who detects enemy targets. Reasonable estimates for the percent of time spent by the crew in various activities are:

If warned:
- 100% driver driving
- 90% others searching
- 10% others misc activities

If unwarned:
- 100% driver driving
- 100% man on watch searching
- 39% of the time other man is asleep
- 61% of the time other man is awake
  - 20% others searching if awake
  - 80% others misc activities if awake

The median response times will be the same as for an onboard crewman in a defensive status.

ANALYSIS

I constructed two small programs* to randomly simulate the reaction times of four tank crews in defense and nine tank crews in the attack and with or without early warning. The programs calculated the time for each crew to become ready to fight its vehicle. In each case, we compared the crew reaction time with and without warning. The crew reaction time is the maximum of the individual crewmen's reaction times, and varies depending on the location, and activity of the individual crewman. These times were sorted to identify the first and last crew ready of the four (or nine) tanks. The times for each of the 101 first crews were then sorted to generate a cumulative probability that first crews were ready in a given time. A similar sorting process generated the cumulative probability that last (fourth or ninth) crews were ready in a given time. The program then printed every fifth value in the cumulative distribution plus the tail values.

RESULTS FOR THE DEFENDER

The most interesting case is for crews in a defensive position. Here, early warning provides the greatest reduction in crew reaction time. Table 1 shows the cumulative probabilities for first and fourth crews with and without early warning. Column 1 gives the percentile values; column 2 gives the crew reaction times for early warning; and column 3 gives the crew reaction times when they have no early warning. Column 4 is the difference. Columns 2-4 are for the first and fastest of the four crews; columns 5-7 are the fourth and slowest ᴄ. the four crews.

Table 1. Crew Response Times for the Defender (seconds)

Percentile	Fastest Crew			Slowest Crew		
	Warned	Unwarned	Diff	Warned	Unwarned	Diff
0	0.11	3.31	3.20	0.30	8.71	8.41
1	0.12	3.54	3.42	0.30	9.49	9.19
2	0.16	3.63	3.47	0.32	9.50	9.18
3	0.16	3.87	3.71	0.32	9.78	9.46
4	0.16	3.95	3.79	0.33	9.80	9.47
5	0.16	3.97	3.81	0.34	10.05	9.71
10	0.18	4.33	4.15	0.42	10.57	10.15
20	0.20	5.04	4.84	0.48	11.50	11.02
30	0.22	5.53	5.31	0.57	12.76	12.19
40	0.24	5.79	5.55	0.68	14.26	13.58
50	0.25	6.27	6.02	1.06	15.30	14.24
60	0.27	6.94	6.67	1.13	17.05	15.92
70	0.29	7.44	7.15	1.28	19.54	18.26
80	0.31	8.14	7.83	1.49	21.51	20.02
90	0.37	9.04	8.67	1.84	24.61	22.77
95	0.42	9.89	9.47	2.43	27.05	24.62
96	0.43	10.07	9.64	2.46	27.67	25.21
97	0.44	10.65	10.21	2.46	28.38	25.92
98	0.44	11.20	10.76	2.46	29.26	26.80
99	0.48	11.58	11.10	3.01	30.28	27.27
100	1.15	12.08	10.93	4.08	32.07	27.99

*See Appendix A.

Under the assumptions stated earlier, on the 50th percentile case, early warning appears to give the fastest crew a 6 second advantage. Other cases yield advantages ranging from 3.2 seconds to 10.9 seconds. Similarly, for the slowest crew, early warning gives a 14.2 second advantage on the 50th percentile case, and extremes from 8.4 to 28 seconds.

RESULTS FOR THE ATTACKER

The attacker appears to benefit less by early warning, since all crewmen are inside the tank. This analysis, however, does not consider the benefits of flank security and surprise, or lack of same.

Table 2 shows the cumulative probabilities for fastest and slowest crews with and without early warning. Again, the first column shows the percentile placement, columns 2-4 are for the fastest crew with and without warning, and columns 5-7 are for the slowest crew with and without warning.

Table 2. Crew Response Times for the Attacker (seconds)

Percentile	Fastest Crew			Slowest Crew		
	Warned	Unwarned	Diff	Warned	Unwarned	Diff
0	0.25	0.29	0.04	1.40	4.84	3.44
1	0.27	0.36	0.09	1.42	5.11	3.69
2	0.28	0.47	0.19	1.45	5.53	4.08
3	0.29	0.49	0.20	1.46	5.77	4.31
4	0.31	0.57	0.26	1.55	5.91	4.36
5	0.33	0.57	0.24	1.58	5.95	4.37
10	0.34	0.62	0.28	1.66	6.29	4.63
20	0.39	0.77	0.38	1.75	7.00	5.25
30	0.43	0.85	0.42	1.94	7.56	5.62
40	0.48	0.96	0.48	2.08	8.22	6.14
50	0.51	1.04	0.53	2.15	9.12	6.97
60	0.55	1.12	0.57	2.32	10.05	7.73
70	0.59	1.23	0.64	2.48	10.54	8.06
80	0.65	1.32	0.67	2.62	11.54	8.92
90	0.75	1.59	0.84	2.99	13.54	10.55
95	0.79	1.75	0.96	3.54	13.86	10.32
96	0.83	1.75	0.92	3.74	14.11	10.37
97	0.84	1.76	0.92	3.95	14.22	10.27
98	0.96	1.78	0.82	4.06	15.03	10.97
99	1.00	1.78	0.78	4.84	19.18	14.34
100	1.07	2.21	1.14	6.98	20.58	13.60

Early warning gives the first and fastest crew a half second advantage in the 50th percentile case, with extremes from 0.04 to 1.14 seconds. Early warning, similarly, gives the ninth and slowest crew a 7 second advantage in the 50th percentile case, with extremes from 3.4 to 13.6 seconds. If you believe the assumptions, early warning is of far more benefit to the defender than to the attacker.

LATER FINDINGS

STANDARD US PRACTICE IN DEFENSE

The U.S. platoon of four tanks follows standard practices in a prepared defense. During daylight, in the absence of warning, the tanks will be in full defilade some distance behind their prepared position with 2 crewmen per platoon forward and searching with binoculars. When the enemy is sighted, 2 of the 4 tanks advance to the prepared position. At night, the two tanks will be in the prepared position using the thermal viewer and night goggles. Since the thermal viewer can only operate on battery power for about 20 minutes, the engine must be on periodically to recharge the batteries. Naturally, this makes the tank more detectable.

THE PEWS EARLY WARNING SYSTEM

U.S. tank platoons currently have one Platoon Early Warning System (PEWS) per platoon. These contain 10 seismic sensors which can be placed a kilometer or so foreward. A panel of lights indicates which sensor is triggered and using the earphones the operator may be able to tell what is shaking the ground. The PEWS sensors use nine volt batteries which must be replaced daily.

The PEWS has several apparent weaknesses. Battery replacement may be hazardous. The enemy may harvest them. They may be ineffective under EW. Appendix B contains some information on this and other early warning systems.

ISRAELI CREW REACTION TIME

Since making the reaction time estimates shown above, I have observed a tape of the TV network program 20-20 with Hugh Downs. This edition high-lighted the Israeli Merkava tank, and showed dismounted Israeli tankers in a drill to mount the tank. Where I estimated 5 seconds to mount a tank and reach combat positions, the Israeli soldiers mounted the tank, while removing gear. At about 15 seconds, the scene abruptly ended but none of the tankers had yet entered the hatches. They were still struggling with their gear. An Abrams master gunner (NCO) who watched the tape says that US tankers have less gear to remove.

In an additional run, the individual reaction times for dismounted defenders were increased by 10 seconds and crew reaction times simulated and sorted. Table 3 shows the results. If this is more representative of the reaction times of individual dismounted crewmen, early warning is even more beneficial. Early warning, here, gives the 50th percentile fastest crew an advantage of 15.6 seconds, with extremes of 4.9 seconds to 31.8 seconds. For the slowest crew, early warning cuts reaction time by 34 seconds, with extremes of 18.6 seconds to 68 seconds.

CONCLUSIONS

1. Early warning appears to provide a definite advantage for the defender.

2. Early warning appears to provide a smaller advantage for the attacker.

3. Real test data would permit a better assessment.

3. The benefits could be further quantified by modeling crew reaction times in a model of tank combat.

Table 3. Crew Response Times for the Defender (seconds)

Percentile	Fastest Crew			Slowest Crew		
	Warned	Unwarned	Diff	Warned	Unwarned	Diff
0	0.11	5.04	4.93	0.30	18.92	18.62
1	0.12	5.47	5.35	0.30	19.09	18.79
2	0.16	5.51	5.35	0.32	19.60	19.28
3	0.16	8.97	8.81	0.32	19.84	19.52
4	0.16	9.43	9.27	0.33	21.21	20.88
5	0.16	9.69	9.53	0.34	22.50	22.16
10	0.18	10.27	10.09	0.42	25.01	24.59
20	0.20	12.32	12.12	0.48	28.18	27.70
30	0.22	13.71	13.49	0.57	30.37	29.80
40	0.24	14.95	14.71	0.68	33.35	32.67
50	0.25	15.88	15.63	1.06	35.16	34.10
60	0.27	16.99	16.72	1.13	38.28	37.15
70	0.29	17.80	18.09	1.28	42.07	40.79
80	0.31	19.83	19.52	1.49	45.64	44.15
90	0.37	23.12	22.75	1.84	51.43	49.59
95	0.42	24.04	23.62	2.43	58.51	56.08
96	0.43	24.16	23.73	2.46	58.96	56.50
97	0.44	24.43	23.99	2.46	60.56	58.10
98	0.44	25.22	24.78	2.46	64.13	61.67
99	0.48	30.22	29.74	3.01	68.89	65.88
100	1.15	31.95	30.80	4.08	72.13	68.05

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APPENDIX A
THE MODEL USED

Here are the programs used to generate the reaction times, a sample input, and a sample output:

```
c     Simulate early warning for defender.
      logical warned, search, echo, trace, awake
      common /cgame / attack, ntanks, men, p(9), dt(8), warned
      real dtmax(0:8), dtfrst(0:100), dtlast(0:100)
1     format(i3,2f6.2)

      call rdgame
      nreps = 101
      DO 80 nrep=0,nreps-1
       DO 30 ntank=0,ntanks-1
        tmax=0.0
        DO 20 man=1,men
c       Find activity of each man.
         IF (man.eq.1) THEN
          t = dt(1) # He is searching (on watch).
          if (.not.warned .and. ran(0).gt.p(1)) t = dt(4) # Searching but outside.
         ELSE
          IF (warned) THEN
c         Crewman is inside.
           search = ran(0).lt.p(2)
           if (search) t=dt(1) # He is searching.
           if (.not.search) t=dt(2) # He is other.
          ELSEIF (ran(0).lt.p(1)) THEN
c         Crewman is inside.
           awake = warned .or. ran(0).lt.p(4)
           IF (awake) THEN
            search = ran(0).lt.p(3)
            if (search) t=dt(1) # He is searching.
            if (.not.search) t=dt(2) # He is other.
           ELSE
            t=dt(3) # He is sleeping.
           ENDIF
          ELSE
c         Crewman is outside.
           awake = warned .or. ran(0).lt.p(4)
           IF (awake) THEN
            search = ran(0).lt.p(3)
            if (search) t=dt(4) # He is searching.
            if (.not.search) t=dt(5) # He is other.
           ELSE
            t=dt(6) # He is sleeping.
           ENDIF
          ENDIF
         ENDIF
        t = t*exp(rolln(0.5))
        if (t.gt.tmax) tmax=t
20      CONTINUE
        dtmax(ntank) = tmax
```

```
30     CONTINUE
       call shell(dtmax,ntanks) # sort tank reaction times for this rep.
       dtfrst(nrep) = dtmax(0)
       dtlast(nrep) = dtmax(ntanks-1)
80    CONTINUE
      call shell(dtfrst,nreps)
      call shell(dtlast,nreps)
      DO 70 i=0,nreps-1
       if (i.le.5 .or. i.ge.95 .or. 0.eq.mod(i,10)) print 1,
     1 i,dtfrst(i),dtlast(i)
70    CONTINUE
      END

      SUBROUTINE RDGAME
      logical echo, trace, warned, attack
      common /crandm/ iseed
      common /contrl/ echo, trace
      common /cgame / attack, ntanks, men, p(9), dt(8), warned
1     format(f7.2,a)

      read *, iseed
      read *, echo, trace
      read *, warned
      read *, ntanks, sleep
      read *, men
      read *, p(1),p(2),p(3)
      read *, (dt(i),i=1,3)
      read *, (dt(i),i=4,6)
      f = (24.0-sleep)/24.0
      p(4) = (men*f-1.0)/(men-1)

      print *, ntanks, 'tanks'
      print *, men, ' man crews.'
      print 1, sleep, ' hrs of sleep per man per day.'
      print *, 'One man is on watch.'
      IF (warned) THEN
       print *, 'Defender is warned.'
       print *, 'All are awake and inside.'
       print 1, p(2), ' prob other man is searching.'
      ELSE
       print *, 'Defender is unwarned.'
       print 1, p(4), ' prob other man is awake.'
       print 1, p(3), ' prob other man is searching if awake.'
       print 1, p(1), ' prob crewman is inside tank.'
      ENDIF
      print *, 'If inside tank:'
      print 1, dt(1), ' reaction time if searching.'
      print 1, dt(2), ' reaction time if other.'
      print 1, dt(3), ' reaction time if sleeping.'
      print *, 'If outside tank:'
      print 1, dt(4), ' reaction time if searching.'
      print 1, dt(5), ' reaction time if other.'
      print 1, dt(6), ' reaction time if sleeping.'
      print *
```

```
      END
      include "u.f"

c     Simulate early warning for attacker.
      integer status
      logical warned, search, echo, trace, awake
      common /stat  / status(4,10)
      common /contrl/ echo, trace
      common /cgame / attack, ntanks, men, p(9), dt(8), warned
      real dtmax(0:8), dtfrst(0:100), dtlast(0:100)
1     format(i3,2f6.2)
3     format(9f7.2)

      call rdgame
      nreps = 101
      DO 80 nrep=0,nreps-1
       DO 30 ntank=0,ntanks-1
        tmax=0.0
        DO 20 man=1,men
c       Find activity of each man (all are inside).
         IF (man.eq.1) THEN
          t = dt(1) # He is searching (on watch).
         ELSEIF (man.eq.2) THEN
          t = dt(2) # He is other (driving).
         ELSE
          IF (warned) THEN
           search = ran(0).lt.p(2)
           if (search) t=dt(1) # He is searching.
           if (.not.search) t=dt(2) # He is other.
          ELSE
           awake = warned .or. ran(0).lt.p(4)
           IF (awake) THEN
            search = ran(0).lt.p(3)
            if (search) t=dt(1) # He is searching.
            if (.not.search) t=dt(2) # He is other.
           ELSE
            t=dt(3) # He is sleeping.
           ENDIF
          ENDIF
         ENDIF
         t = t*exp(rolln(0.5))
         if (t.gt.tmax) tmax=t
20      CONTINUE
        dtmax(ntank) = tmax
30     CONTINUE
       call shell(dtmax,ntanks) # sort tank reaction times for this rep.
       if (trace) print 3,(dtmax(ntank),ntank=0,ntanks-1)
       dtfrst(nrep) = dtmax(0)
       dtlast(nrep) = dtmax(ntanks-1)
80    CONTINUE
      if (trace) print 3, (dtfrst(i),i=0,nreps-1)
      if (trace) print 3, (dtlast(i),i=0,nreps-1)
      call shell(dtfrst,nreps)
      call shell(dtlast,nreps)
```

```
      DO 70 i=0,nreps-1
       if (i.le.5 .or. i.ge.95 .or. 0.eq.mod(i,10)) print 1,
    1  i,dtfrst(i),dtlast(i)
70    CONTINUE
      END

      SUBROUTINE RDGAME
      logical echo, trace, warned, attack
      common /crandm/ iseed
      common /contrl/ echo, trace
      common /cgame / attack, ntanks, men, p(9), dt(8), warned
1     format(f7.2,a)

      read *, iseed
      read *, echo, trace
      read *, warned, attack
      read *, ntanks, sleep
      read *, men
      read *, p(1),p(2),p(3)
      read *, (dt(i),i=1,3)
      read *, (dt(i),i=4,6)
      f = (24.0-sleep)/24.0
      p(4) = (men*f-1.0)/(men-1)

      print *, 'random seed =', iseed
      if (.not.trace) print *, 'trace off'
      print *, ntanks, 'tanks'
      print *, men, ' man crews.'
      print 1, sleep, 'hrs of sleep per man per day.'
      print *, 'One man is on watch, one is driving.'
      IF (warned) THEN
       print *, 'Attacker is warned.'
       print *, 'All are awake'
       print 1, p(2), ' prob other man is searching.'
      ELSE
       print *, 'Attacker is unwarned.'
       print 1, p(4), ' prob other man is awake.'
       print 1, p(3), ' prob other man is searching if awake.'
      ENDIF
      print 1, dt(1), ' reaction time if searching.'
      print 1, dt(2), ' reaction time if other.'
      print 1, dt(3), ' reaction time if sleeping.'
      print *
      END
      include "u.f"

c     File u.f
      FUNCTION RAN (dm)
c 9   Ran: A version of uran31 random uniform nr generator. iseed=1111111
      real a1
      common /crandm/ iseed
c     save iseed
c
      j=iseed
```

```
      j=j*25
      j=j-(j/67108864)*67108864
      j=j*25
      j=j-(j/67108864)*67108864
      j=j*5
      j=j-(j/67108864)*67108864
      a1=j
      iseed=j
      ran= a1/67108864
      END

      FUNCTION ROLLN(sigma)
c 6   Rolln: find a random number from a normal distribution.
c     Box-Muller method
      save j, z
      data j/0/
c
      IF (j.eq.0) THEN
       x = sqrt(-2.*alog(ran(dm)))
       y = 2.*3.1415926535*ran(dm)
       rolln = x*cos(y)*sigma
       z = x*sin(y)
      ELSE
       j = 1-j
       rolln = z*sigma
      ENDIF
      END
c
      SUBROUTINE SHELL (v,n)
c     Purpose: perform shell sort.
c     Ref - The C Programming Language, p58
      real v(0:199)
      integer gap
c
      gap = n/2
      DO 90 igap=1,15
       IF (gap.le.0) GOTO 99
        DO 80 i=gap,n-1
         j = i-gap
         DO 70 k=1,9999
          IF (j.lt.0 .or. v(j+gap).ge.v(j)) GOTO 71
          temp = v(j)
          v(j) = v(j+gap)
          v(j+gap) = temp
          j = j-gap
70       CONTINUE
71       CONTINUE
80      CONTINUE
       gap = gap/2
90    CONTINUE
99    CONTINUE
      END
```

Sample input:

1111111, random number seed
T,F, echo, trace
F,F, warned, attack
4,7.0, ntanks, sleep (hrs)
4 men in crew
0.3,.9,.2, prob: on-board, search if warn, search if unwarn & awake
0.2,1.,5., on board - delay if searching, other, sleeping
5.,6.,10., dismounted - delay if searching, other, sleeping

Sample output:

```
 4 tanks
 4  man crews.
 7.00 hrs of sleep per man per day.
 One man is on watch.
 Defender is unwarned.
  0.61 prob other man is awake.
  0.20 prob other man is searching if awake.
  0.30 prob crewman is inside tank.
 If inside tank:
  0.20 reaction time if searching.
  1.00 reaction time if other.
  5.00 reaction time if sleeping.
 If outside tank:
  5.00 reaction time if searching.
  6.00 reaction time if other.
 10.00 reaction time if sleeping.

  0 3.31  8.71
  1 3.54  9.49
  2 3.63  9.50
  3 3.87  9.78
  4 3.95  9.80
  5 3.97 10.05
 10  4.33 10.57
 20  5.04 11.50
 30  5.53 12.76
 40  5.79 14.26
 50  6.27 15.30
 60  6.94 17.05
 70  7.44 19.54
 80  8.14 21.51
 90  9.04 24.61
 95  9.89 27.05
 96 10.07 27.67
 97 10.65 28.38
 98 11.20 29.26
 99 11.58 30.28
100 12.08 32.07
```

APPENDIX B
EARLY WARNING SYSTEMS

The following is a list[4] of ground based early warning systems. Other early warning systems would include remotely piloted vehicles, space based systems, and early warning from other reconnaisance systems or weapon systems.

US early warning systems:

Battlefield Surveillance Radar AN/PPS-5B
Range: (men) 5km, (vehicles) 10km
Accuracy: (range) +-20m, (azimuth) +-10 mils
also have tripod mounted version on jeep

Battlefield Surveillance Radar AN/PPS-6
Range: (men) 1.5km, (vehicles) 3km
Accuracy: (range) +- 25m, (azimuth) +-18mils
tripod mounted

PEWS (Platoon Early Warning System) AN/TRS-2(V)
Tgt detection range: 10m
Data link range: 1.5km
10 sensors, 2 receivers per system
Detects via seismic, magnetic signature
hand emplaced. 9 volt batteries last a day.

REMBASS ground sensor system
Detects via IR, acoustic, seismic, mechanical, magnetic, etc
Emplaced by hand, artillery, or air. Batteries last a week, then entire units are replaced.
Range: (men) 10m, (vehicles) 100m

Soviet early warning systems:

PSNR-1 Battlefield information gathering station
tripod mounted, man portable
Range (est): (men) 5km, (vehicle) 10km

[4] "Jane's Infantry Weapons 1985-86," Jane's Publishing Company, NY, p 827.

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